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# Proposed Budget



## Fiscal Year 2009

### Capital Improvements Program, Volume III

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## Water

### Municipal Water

#### Groundwater Asset Development Program 75-932.0

Council District: Citywide

Community Plan: Citywide

**Description:** This project provides for investigation work related to legal, technical, regulatory, and water quality issues; and for the planning, design, and construction of groundwater facilities to increase the local water supply.

**Justification:** The City imports 90 percent of its water from the Colorado River and the State Water Project. The City has access to nine under-utilized groundwater assets that could be developed to supply new yield, seasonal storage or carryover storage.

**Operating Budget Effect:** The operating budget effect will be determined upon completion of design.

**Relationship to General and Community Plans:** This project is in compliance with applicable community plans and is in conformance with the City's Progress Guide and General Plan.

**Scheduling:** Research, exploration and demonstration began in Fiscal Year 2001 and will continue through Fiscal Year 2010. Design and construction of subprojects identified in the research/exploration/demonstration phase are anticipated to begin in Fiscal Year 2010 and continue through Fiscal Year 2019 and beyond.

**Summary of Project Changes:** The scope and schedule of this project are still preliminary.

Expenditures by Revenue Source								
Revenue Source/Tag	Fund	Exp/Enc	Con Appn	FY2009	FY2010	FY2011	FY2012	FY2013
WATER-R	041500	7,737,767	966,763	2,981,094	11,676,854	15,612,745	14,214,200	2,909,854
Total		7,737,767	966,763	2,981,094	11,676,854	15,612,745	14,214,200	2,909,854
Work Codes		CD	D	D	CD	C	C	C
Revenue Source/Tag	Fund	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Total
WATER-R	041500	5,651,300	19,461,703	10,785,283	5,583,753	146,127	86,427	97,813,870
Total		5,651,300	19,461,703	10,785,283	5,583,753	146,127	86,427	97,813,870
Work Codes		C	C	C	C	C	C	

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## 3.17 WATER QUALITY

### 3.17.1 Existing Conditions

#### Surface/Receiving Waters

The major receiving waters within the City of San Diego include the Pacific Ocean, San Diego Bay, Mission Bay, the San Dieguito River, Los Peñasquitos Creek, the San Diego River, the Otay River and the Tijuana River (**Figure 3.7-2**). Major reservoirs include Barrett, El Capitan, San Vicente, Hodges, Miramar, Murray, Lower Otay, Upper Otay, and Sutherland. Additionally there are minor receiving waters made up of creeks, channels, streams and lagoons.

#### Groundwater

The geography of San Diego provides limited natural local supplies in the form of groundwater, and it is not currently considered a useable potable water resource. With the close proximity to the ocean and the shallow location of the water table, groundwater and ocean water mix subsurface and become brackish. In order to become usable, much of the available groundwater would need to undergo desalination. The Water Department has studied numerous potential groundwater supply options and has an ongoing Capital Improvement Project to continue to develop potential groundwater resources including groundwater desalination, but there is not any active use of potable groundwater at this time. Potential groundwater supplies are estimated at 6,000 – 20,000 AFY, but the current cost of utilizing the supply with existing technology is infeasible.

#### City of San Diego's Water Quality

Many of the City's water bodies harbor sensitive biotic communities easily affected by added pollutant discharges; the quality of sensitive bodies of surface water varies. Certain reservoirs, particularly the Hodges Reservoir, have experienced high Total Dissolved Solids (TDS) levels due to the introduction of Colorado River water and high evaporation rates. Typical pollutants include dissolved solids, nutrients such as nitrate and phosphate, organic materials, bacteria, heavy metals, pesticides, and toxic industrial wastes. Sedimentation from unprotected construction sites is a water quality problem that is altering certain sensitive lagoons. Accumulation of trash within receiving waters is also contributing to the impairment of the City's water resources. The City's water bodies are also susceptible to eutrophication, which is characterized by an abundant accumulation of nutrients that support a dense growth of algae and other organisms, the decay of which depletes shallow waters of oxygen in summer.

Section 303(d) of the Clean Water Act requires states to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, streams and coastal regions that fall short of state water quality standards, and are not expected to show improvement in the next two years. Portions of water bodies within the City of San Diego which were listed as impaired in 2002 are listed on **Table 3.17-1**.

**Table 3.17-1**  
**Impaired Water Bodies with the City of San Diego**

<b>Water Body</b>	<b>% of Total</b>
Chollas Creek	Bacterial Indicators, Cadmium, Copper, Lead, Diazinon, Zinc
Famosa Slough and Channel	Eutrophic
Hodges Reservoir	Color, Nitrogen, Phosphorus, TDS
Los Peñasquitos Lagoon	Sedimentation
Mission Bay	Eutrophic, Bacterial Indicators, Lead
Pacific Ocean Shoreline	Bacterial Indicators
San Diego Bay	Bacterial Indicators, Chlorade, Copper, Degraded Benthic Comm., Lindade, Mercury, PAHs, PCBs, Sediment Toxicity, Zinc
San Diego River	Fecal Coliform, Dissolved Oxygen, Phosphorus, TDS
Tecolote Creek	Bacterial Indicators, Cadmium, Copper, Lead, Toxicity, Zinc
Tijuana River	Bacterial Indicators, Low Dissolved Oxygen, Eutrophic, Pesticides, Solids, Synthetics Organics, Trace Elements, Trash
Tijuana River Estuary	Bacterial Indicators, Eutrophic, Lead, Nickel, Pesticides, Thallium, Trash, Dissolved Oxygen

Source: RWQCB, 2002

### Water Pollutant Sources

Sources of pollutants can be classified as two types: point and nonpoint sources. Point sources of water pollutants are defined as sources from which wastewater is transmitted in some type of conveyance (pipe and channel) to a water body, and are classified as municipal or industrial sources. Municipal point sources consist primarily of domestic treated sewage and processed water. Industrial point sources are primarily from such operations as sand and gravel extraction; livestock and dairy operations; trailer park, park, and camp development; electrical power generation; metal plating and printed circuitry etching; operations associated with shipbuilding and repair; and wastes from federal, commercial, and recreational vessels.

Nonpoint sources are those sources of water pollutants which do not discharge to a watercourse from a pipe. This pollution arises from many everyday activities that take place in residential, commercial, and rural areas and is carried by storm water runoff to streams. Nonpoint sources, however, have been suspected of causing significant water quality problems. In urban areas, the storm water runoff from streets likely carries considerable quantities of harmful materials, such as oil, rubber, metals (including lead), pathogens, trash, and other solids. In addition, increased peak flows from roadway runoff can also alter the hydraulics of an area by scouring and transporting and depositing sediments in areas lower than the runoff source.

## **Regulatory Setting**

Water resources are protected under the mandates of numerous federal, state and local jurisdictional laws, regulations, plans and ordinances and these must be considered in the early planning stages of any project. Future projects implemented under the General Plan will be required to adhere to the requirements of these regulations.

### ***Federal***

**Clean Water Act.** This act is the principle law governing pollution control and water quality of the nation's waterways. The objective of this act is to restore and maintain the chemical, physical and biological integrity of the nation's waters (33 U.S.C. 1251). Section 402 of the Clean Water Act controls water pollution through the National Pollutant Discharge Elimination System (NPDES), by regulating point sources that discharge pollutants into waters of the U.S. Implementation of the act is the responsibility of the Environmental Protection Agency (EPA), which has delegated much of that authority to state and regional agencies.

### ***State of California***

**The Dickey Act.** Enacted by the State of California in 1949, this Act created the nine Regional Water Pollution Control Boards (now referred to as the Regional Water Quality Control Boards) and sought to establish statewide water quality objectives. Initially these boards only established narrative objectives for discharges, but in 1952 they were further charged with establishing numerical limits for discharges and adopting water quality objectives for receiving waters.

**Porter-Cologne Water Quality Act of 1969.** This Act gave the power to the Regional Water Quality Control Boards (RWQCB) to establish water quality plans for each region. In 1975, a Comprehensive Water Quality Control Plan Report for each region was established (commonly referred to as the Basin Plan). These plans compiled all of the existing beneficial uses, water quality objectives, and policies into one document and rescinded all individually adopted objectives and policies. Also included were the control of point source discharges and the development of new programs to address nonpoint source pollution issues in the regions.

Since 1975, the individual Basin Plans have been amended on numerous occasions. Components of the Basin Plan are reviewed as new data and information become available or as specific needs arise. Many new issues and areas of concern have risen as health scientists have identified increasingly lower concentrations of toxic substances as health risks. Because of this, water quality objectives have to be constantly reexamined to maintain levels that are safe for the public. In addition all plans that can affect water quality are incorporated into the planning process. A comprehensive update of each Basin Plan occurs tri-annually in response to state and federal legislative requirements, and as funding becomes available.

**State Water Resources Control Board (SWRCB) Construction General Permit, 99-08-DWQ.** Construction activities that disturb one or more acres of land that could impact hydrologic resources must comply with the requirements of this permit. To be in compliance, the applicant for a construction permit must file a complete and accurate Notice of Intent with the SWRCB.

Compliance requires conformance with applicable Best Management Practices (BMPs) and development of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must contain a site map(s) which shows the construction site perimeter, existing and proposed buildings, lots, roadways, storm water collection and discharge points, general topography both before and after construction, and drainage patterns across the project.

### ***Local***

**San Diego Regional Water Quality Control Board (RWQCB or Water Quality Board) Order No. R9-2007-0001.** In January of 2007, under the authority of the Clean Water Act amendments and federal NPDES Permit regulations, the Water Quality Board re-issued the order to the 18 cities within San Diego County, the county of San Diego, the Port of San Diego, and the San Diego Regional Airport Authority (Copermittees). Commonly referred to as the “Municipal Permit,” this order requires that all Copermittees within the San Diego region prepare Jurisdictional Urban Runoff Management Plans (JURMPs). Each JURMP must contain a component addressing land use planning for new development and redevelopment, construction, existing development, education, illicit discharge detection and elimination, public participation, effectiveness assessment and fiscal analysis. In addition, the Municipal Permit requires that Copermittees collaborate on the development of a Watershed Urban Runoff Management Plan (WURMP) for each watershed, which addresses high priority storm water quality issues found within the various watersheds.

**City of San Diego Jurisdictional Urban Runoff Management Program (JURMP).** This document is a total account of how the City of San Diego plans to protect and improve the water quality of rivers, bays and the ocean in the region in compliance with the RWQCB Order No. R9-2007-01. The document describes how the City incorporates storm water BMPs into land use planning, development review and permitting, City capital improvement program project planning and design, and the execution of construction contracts.

**Watershed Urban Runoff Management Programs (WURMPs)** The City of San Diego participated in the drafting of five WURMPs that document high priority storm water quality issues found within the following watersheds: San Dieguito, Los Peñasquitos, San Diego River, San Diego Bay (comprised of Pueblo, Sweetwater and Otay) and Tijuana. The City was the lead agency on the San Dieguito, Los Peñasquitos, and San Diego River documents. These WURMPs identify and prioritize water quality-related issues within each watershed that can be potentially attributed to discharges from the municipal storm drain systems. The reports describe the watershed in detail, characterize the water quality impairments (provide a baseline of data for future analysis), and set up an action plan explaining how the municipalities will collaborate to improve water quality.

**City of San Diego Storm Water Standards Manual.** This manual requires that urban runoff pollution issues be specifically addressed in development planning for public and private projects. In addition to considering alternative site design approaches and instituting source controls (i.e. methods to keep pollutants out of contact with storm water), structural treatment devices or storm water BMPs are required.

### 3.17.2 Thresholds of Significance

A significant impact could occur if implementation of the General Plan:

- Results in a substantial increase in pollutant discharge to receiving waters and increase discharge of identified pollutants to an already impaired water body;
- Impacts local and regional water quality or supply, including groundwater.

### 3.17.3 Impact Analysis

***Could implementation of the Draft General Plan result in a substantial increase in pollutant discharge to receiving waters and increase discharge of identified pollutants to an already impaired water body?***

The Draft General Plan calls for most future growth to be focused into mixed-use activity centers. Implementation of the Plan would result in infill and redevelopment occurring in selected built areas, which would be identified through the community plan update/amendment process. The Draft General Plan would also guide the development of remaining developable vacant land. Almost all the pollutants found in the impaired water bodies with the City have anthropogenic (man-made) origins; therefore increasing the population could increase the amount of pollution entering the aquatic ecosystem. Redevelopment and infill activities in urbanized areas could result in an increased amount of impervious surfaces. In addition, most development of vacant land could also decrease permeability.

These impervious surfaces would result in increased runoff, adding to local non-point source pollution. Chemical pollutants contained in runoff would be primarily attributable to motor vehicles, which contribute particulate materials from fuel combustion, petroleum products, metals, rubber, and asbestos to roadway pollutants. In addition, a potential would exist for biologically active chemicals such as herbicides and fertilizers and fecal matter from pets and wildlife to contribute pollutants. These pollutants accumulate on paved surfaces and adjacent areas; rain flushes the pollutants into storm drains and into natural drainages, and they are eventually deposited into the aquatic environment (i.e., lagoons, rivers, and lakes). Therefore, additional anthropologic sources and impervious surfaces created by future development as anticipated in the Draft General Plan could create additional sources of polluted runoff and constitute a significant impact.

Although no physical changes or development is proposed with the Draft General Plan, as the plan would be implemented in association with community plans and regulations, development could also cause erosion due to exposed graded surfaces, excavation, stock piling, or boring, and would potentially contribute to the sediment load in surface waters. Deposition of sediments downstream may be significant if they are introduced into a potable water supply (reservoirs), flood control channels, or wetlands. Increased deposition of sediments into water bodies can result in increased turbidity, clog streambeds, degrade aquatic habitat, and interfere with flow.

The General Plan Village Propensity Map identifies areas that already exhibit village characteristics, and areas that may have a propensity to develop as villages due to existing or community plan designated multifamily housing, parks, schools, fire stations, and higher frequency transit routes. Although actual village locations will be determined by forthcoming community plan updates and have not been determined at this time, the Propensity Map identifies areas where village designations are more likely to occur. Certain impaired water bodies are in close proximity to areas identified in the Village Propensity map as high propensity. These water bodies include Los Peñasquitos Lagoon, Pacific Ocean Shoreline, Mission Bay, Tecolote Creek, San Diego River, San Diego Bay Shoreline, Chollas Creek, and the Tijuana River. Future land use proposals near these areas with impairments will require strict compliance with all existing regulations pertaining to pollutant discharges to ensure that impairments will not be worsened. As the Draft General Plan is implemented, all future developments will also be required to comply with all existing regulations pertaining to pollutant discharges to avoid the creation of new water quality impairments within the receiving waters throughout the City.

Within the Draft General Plan, specific policies have been put in place in order to limit pollutant discharge to receiving waters and the discharge of identified pollutants to an already impaired water body. Specific policies that address potential water quality impacts include the following:

- CE-E.1 1. Continue to develop and implement public education programs;
- CE-E.2 2. Apply water quality protection measures to land development projects early in the process (during project design and operations) in order to minimize the quantity of runoff generated on-site, the disruption of natural water flows and the contamination of storm water runoff;
- CE-E.3 3. Require contractors to comply with accepted storm water pollution prevention planning practices for all projects;
- CE-E.4 4. Continue to participate in the development and implementation of Watershed Management Plans for water quality and habitat protection;
- CE-E.5 5. Assure that City departments continue to use “Best Management Practice” procedures so that water quality objectives are routinely implemented;
- CE-E.6 6. Continue to encourage “Pollution Control” measures to promote the proper collection and disposal of pollutants at the source, rather than allowing them to enter the storm drain system;
- PF-G.1 7. Ensure that all storm water conveyance systems, structures, and maintenance practices are consistent with federal Clean Water Act and California Regional Water Quality Control Board NPDES Permit standards;
- PF-G.2 8. Install infrastructure that, where feasible, includes components to capture, minimize, and prevent pollutants in urban runoff from reaching receiving waters and our potable water supplies;
- PF-G.3 9. Meet or exceed regulatory mandates in a cost-effective manner monitored through performance measures;
- PF-G.4 10. Develop and employ a strategic plan ~~Master Drainage Plans~~ for the City’s watersheds to foster a comprehensive approach to storm water infrastructure improvements; and

~~PF G.5~~ 11. Identify and implement BMPs for projects that repair, replace, extend or otherwise affect the storm water conveyance system. These projects should also include design considerations for maintenance, inspection, and, as applicable, water quality monitoring.

The above policies, along with adherence to federal, state, and local water quality regulations, serve to preclude or reduce significant impacts to a degree, but cannot guarantee that all future project level impacts will be avoided or mitigated to a level less than significant. Therefore, impacts associated with pollutant discharge may be significant at the program level. The Mitigation Framework has been identified to reduce these program level impacts.

New pollutants of concern may be identified for which a suitable treatment BMP may not be identified in the applicable regulations. In which case, their impacts may not be precluded or mitigating to a level less than significant.

The Mitigation Framework requires future development projects to be sited and designed to minimize impacts to receiving waters, in particular the discharge of identified pollutants to an already impaired water body. Prior to approval of any permit for a future project, the City must ensure that any impacts to receiving waters are precluded or, where necessary, mitigated in accordance with the requirements of the City of San Diego and other appropriate agencies (e.g., SDRWQCB). In accordance with the City of San Diego Stormwater Standards Manual, development must be designed to incorporate stormwater improvements, both off- and on-site. Because the degree of impact and applicability, feasibility, and success of these measures cannot be adequately known for each specific project at this program level of analysis, the program level impact related to pollutant discharge may remain significant and unavoidable.

***Could implementation of the Draft General Plan otherwise impact local and regional water quality, including groundwater?***

As mentioned above, the implementation of the Draft General Plan anticipates that future growth will likely occur in existing urbanized areas and that community plan amendments and updates will identify areas to focus this growth. Increased pollution discharge, resulting from the growth in population around transit corridors, has the potential to otherwise create a significant impact to local and regional water quality. Because most of the water bodies in San Diego are part of a hydrologic system, rather than stand alone entities, water pollution anywhere in the system has the potential to affect the entire system. The local hydrologic system does not follow jurisdictional boundaries, thus all jurisdictions cooperatively work to reduce impacts to the water quality of the region. This cooperation is established under the NPDES Municipal Permit, which requires Copermittees to collaborate on the development of a WURMP for each watershed. The WURMP documents address high priority storm water quality issues found within the various watersheds. Under the Draft General Plan, policies have been established to ensure that the City complies with the WURMP documents. Those policies include: ~~CE E.4~~ Continue to participate in the development and implementation of Watershed Management Plans for water quality and habitat protection; and ~~PF G.6~~ Pursue Identify partnerships and collaborative efforts to sponsor and coordinate pollution prevention BMPs that benefit storm water infrastructure maintenance and improvements. The above

policies serve to reduce impacts to a degree, but cannot guarantee that all future project level impacts will be avoided or mitigated to a level less than significant.

Compliance of the WURMP documents by the City of San Diego and other jurisdictions within the region's watersheds will also help prevent or reduce significant water quality impacts from individual jurisdictions as well as collective impacts from all jurisdictions within the watershed. Although a small project within a single community may not impact regional water quality, when considered collectively with all projects within the watershed, there is the potential for significant environmental impact from the amalgamation of other closely related projects. Any pollution caused by growth within the City of San Diego would be combined with pollution from growth from other cities, which collectively could impact local and regional water quality. Therefore, strict compliance with the WURMP documents is essential to prevent or reduce significant impacts to regional water quality. Although every measure will be taken to limit individual and collective water quality impacts through the WURMP process, strict compliance by all project proponents in all jurisdictions cannot be guaranteed. Therefore, there is the potential for significant impacts to regional water quality at the program level.

Future growth and development also has the potential to create impacts to groundwater quality. Groundwater degradation takes three forms: stock depletion, contamination, and secondary problems such as land subsidence and saline intrusion. Historically and presently, groundwater is not considered a source of potable water for the City, although small amounts have been used for irrigation purposes. There are several groundwater sources throughout San Diego County; however, there are challenges associated with their development. The San Diego Formation appears to be the major aquifer in the vicinity of the City, and due to its confined characteristics, it does not appear to recharge naturally at a useful rate. In addition, San Diego's four main alluvial basins contain brackish groundwater, which may require desalination before the supply could be used for potable use. Additionally, there could also be potential inter-jurisdictional and water rights issues regarding the City's use of the basins because they extend beyond the boundaries of the City's overlaying land. Since groundwater is not considered a source of potable water, there are no significant impacts from stock depletion as well as land subsidence or new saline intrusion anticipated.

As with urban runoff, groundwater contamination can often be traced to anthropogenic sources. Illegal dumping can lead to groundwater impacts. If a site is subject to illegal dumping, contaminants from the surface have the potential to percolate through soils into the groundwater, thus contaminating it. As more people are introduced to a community and more development occurs, there is greater potential for groundwater degradation from these anthropogenic sources. Although groundwater is not considered a water resource within the plan area, there is potential for utilization in the future. As such, protecting groundwater quality will be necessary for future use. Although compliance with all water quality standards and guidelines will be instituted by the City, strict observance of all regulations cannot be guaranteed communitywide.

Implementation of the above policies and compliance with the WURMP would serve to avoid or reduce impacts to a degree, but cannot guarantee that all future project level impacts will be avoided or mitigated to a level less than significant. Because the degree of impact and applicability, feasibility, and success of water quality protection these measures cannot be

accurately predicted for each specific project at this time, the program-level impact related to local and regional water quality is considered significant and unavoidable.

#### 3.17.4 Mitigation Framework

Goals, policies, and recommendations enacted by the City combined with the federal, state and local regulations described above provide a framework for developing project-level water quality protection measures for future discretionary projects. The City's process for the evaluation of discretionary projects includes environmental review and documentation pursuant to CEQA as well as an analysis of those projects for consistency with the goals, policies and recommendations of the General Plan. In general, implementation of the above policies and compliance with the WURMP would preclude water quality impacts. Compliance with the standards is required of all projects and is not considered to be mitigation. However, it is possible that for certain projects, adherence to the regulations may not adequately protect water quality, and such future projects would require additional measures to avoid or reduce significant water quality impacts. These additional measures would be considered mitigation.

For each future discretionary project requiring, mitigation (i.e., measures that go beyond what is required by existing regulations), site-specific measures will be identified that reduce significant project-level impacts to less than significant or the project-level impact may remain significant and unavoidable where no feasible mitigation exists. Where mitigation is determined to be necessary and feasible, these measures will be included in a Mitigation Monitoring and Reporting Program (MMRP) for the project. Below is a summary of general measures that may be implemented to preclude impacts. These measure may be updated, expanded and refined when applied to specific future projects based on project-specific design and changes in existing conditions, and local, state and federal laws. The Mitigation Framework is as follows:

- Future projects must be sited and designed to minimize impacts to receiving waters, in particular the discharge of identified pollutants to an already impaired water body. Prior to approval of any entitlement for a future project, the City must ensure that any impacts to receiving waters will be precluded and, if necessary, mitigated in accordance with the requirements of the City of San Diego and other appropriate agencies (e.g., RWQCB). To prevent erosion, siltation, and transport of urban pollutants, future development must be designed to incorporate any applicable stormwater improvements, both off- and on-site in accordance with the City of San Diego Stormwater Standards Manual. Stormwater improvements and water quality protection measures that may be required of future developments, include:
  - Increasing on-site filtration.
  - Preserving, restoring or incorporating natural drainage systems into site design.
  - Directing concentrated flows away from MHPA and open space areas. If not possible, drainage must be directed into sedimentation basins, grassy swales or mechanical trapping devices prior to draining into the MHPA or open space areas.
  - Reducing the amount of impervious surfaces through selection of materials, site planning, and the narrowing of street widths, where possible.

- Increasing the use of vegetation in drainage design.
- Maintaining landscape design standards that minimize the use of pesticides and herbicides.
- To the extent feasible, avoiding development of areas particularly susceptible to erosion and sediment loss.

### 3.17.5 Significance of Impact with Mitigation Measures

Because the degree of future impacts and applicability, feasibility, and success of future mitigation measures cannot be adequately known for each specific future project at this program level of analysis, the program-level impacts related to water quality remains significant and unavoidable.

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infrastructure is estimated to be \$5 million, while the O&M costs are estimated to be \$0.5 million per year.

Therefore, the total estimated cost of an 8.9 mgd ocean desalination plant, including the distribution costs to deliver the treated water to the City's customers is approximately \$1,400 per acre-foot.

### 3.4 Groundwater Desalination and Conjunctive Use Storage

Groundwater resources maybe one of the most promising local supply opportunities for the City. There are eight major groundwater basins that are of interest to the City for supply development (see Figure 3-3):

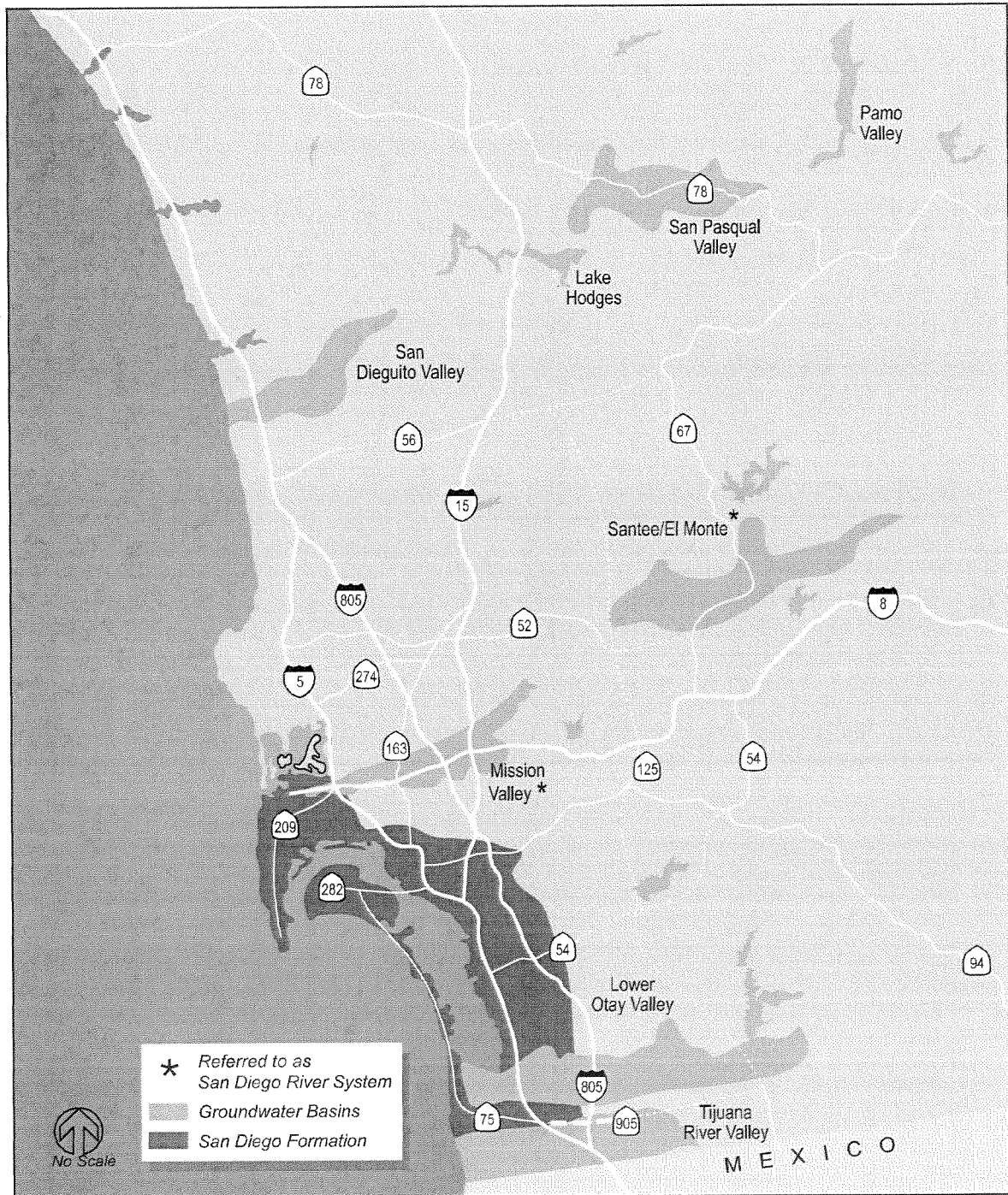
- San Pasqual Valley Basin
- San Dieguito Valley Basin
- Santa Maria Basin
- Mission Valley Basin\*
- Santee/El Monte Basin\*
- Middle Sweetwater River Basin
- Lower Sweetwater River Basin
- Tijuana River Valley Basin
- San Diego Formation Aquifer

*\* Typically referred to as San Diego River System*

San Pasqual Valley, Santa Maria, Santee/El Monte (part of San Diego River System), and Middle Sweetwater River are alluvial inland basins. Alluvial inland basins are hydraulically isolated from the ocean and have limited areas where natural outflow takes place. These basins are ideal for storage and maintaining safe yield.

San Dieguito Valley, Mission Valley (part of San Diego River System), Lower Sweetwater River, and Tijuana Valley are alluvial shoreline basins. Alluvial shoreline basins likely have hydraulic interaction with the ocean and, therefore, management options would likely be needed to address this factor.

San Diego Formation appears to be a confined aquifer system, which has a much greater aerial extent. It is also likely to have hydraulic interaction with the ocean.



Map shows relative locations of basins only. Not to scale.

**Figure 3-3**  
**Major San Diego Groundwater Basins**

In 1983 and 1985, the USGS published reports summarizing data collection for many of these groundwater basins. A subsequent report prepared by Boyle Engineering Corporation (1995), summarized the USGS studies. Much of the safe yield and water quality data is over two-decades old and it is likely that conditions have changed.

The City is currently investigating five of the groundwater basins to determine their feasibility for development. The City sees these basins as a local asset and a way to improve its water supply. The City is completing a master plan for groundwater development, and is moving ahead with field studies for the San Diego River System, San Dieguito Valley, San Pasqual Valley, Lower Tijuana River Valley, and San Diego Formation. Field studies, through drilling exploratory wells, will be used to determine safe yield (inflow and outflows), water quality, and other basin characteristics.

### **3.4.1 Supply Potential**

For planning purposes, the supply potential for these basins was based on the Boyle Engineering Corporation (1995) report. However, it should be noted that actual supply yield and cost could be significantly different, based on the outcome of the City's investigation and field study.

There are two types of supply that these groundwater basins could provide: (1) safe yield production, providing a yearly supply; and (2) conjunctive use storage of imported and/or reclaimed water, providing a dry year supply.

#### ***Groundwater Desalination (safe yield production)***

Based on prior reports, it is likely that safe yield production from these basins would require treatment (desalination). Similar to ocean desalination, groundwater desalination is the process whereby dissolved minerals are removed from saline or brackish groundwater (see Figure 3-2 in Section 3.3).

The most likely development range of safe yield supply from these basins is 6,000 to 20,000 AFY. It is assumed that natural recharge is sufficient for this range of safe yield. The safe yield, with treatment, could be used for both potable and non-potable purposes, as well as for average annual and peak demands.

Depending on which basin(s) are developed, the cost for groundwater desalination could involve the following components:

- Desalination treatment facility
- Brine disposal lines
- Groundwater production wells
- Interconnection facilities to move groundwater supply to City's water delivery system (e.g., pump stations, pipelines, etc.)

A planning-level cost analysis indicates that groundwater desalination could range from \$650 to \$1,200 per acre-foot, depending on level of treatment, pumping, and location of basin relative to the City's water delivery system.

### ***Groundwater Conjunctive Storage (dry year production)***

Another potential benefit of these groundwater basins is conjunctive use storage. Conjunctive use storage is the process by which non-native water supply is artificially recharged into the basin to produce a supply yield. Whereas safe yield supply requires that natural runoff and rainfall replenish the groundwater, conjunctive use storage can offer increased supply where little or no natural replenishment is available. Conjunctive use storage of the groundwater basins can essentially operate like an underground surface reservoir. There are four possible ways for the City to store non-native water in the groundwater basins for storage:

- Treated water injected into the groundwater basins through injection wells
- Untreated water percolated into the groundwater basins through natural or man-made spreading basins
- Reclaimed water injected into the groundwater basins through injection wells
- Reclaimed water percolated into the groundwater basins through natural or man-made spreading basins

It should be noted that the use of reclaimed water for groundwater storage would limit the supply production for non-potable uses only. The City would not store reclaimed water in groundwater basins used for potable demand.

Table 3-3 summarizes the potential for groundwater conjunctive use storage for three basins. These estimates were generated using the Boyle Engineering Corporation (1995) report. There may be additional storage potential in the other basins, which will be determined through the City's field investigations.

Table 3-3 Groundwater Conjunctive Use Storage Potential for Three Groundwater Basins			
Groundwater Basin	Maximum Storage (AF)	Recoverable Storage – Supply Yield (AFY)	Artificial Recharge (AFY)
San Pasqual Basin	60,000	20,000	29,000
San Diego River System	70,000	18,000	26,000
San Diego Formation	200,000	10,000	14,000
Total	330,000	48,000	69,000

Costs for groundwater conjunctive use storage, depending on the source of stored water (e.g., imported vs. reclaimed) and need for treatment, may involve the following components:

- Groundwater production and/or injection wells
- Pre or post treatment (filtration, purification)
- Spreading basins
- Interconnection facilities to move groundwater supply to City's water delivery system
- Cost of imported and/or reclaimed water.

A planning-level cost analysis indicates that groundwater conjunctive use storage could range from \$550 to \$700 per acre-foot, depending pumping, need for treatment, source of replenishment water, and distance of basin relative to City's water deliver system.

### **3.4.2 Development Issues**

There are numerous issues that should be evaluated when considering the development of groundwater resources. Groundwater desalination development issues will be similar to those discussed in Section 3.3.2. However, the following are several other development issues specific to groundwater:

- Interjurisdictional and water rights issues
- Potential impacts to groundwater basins (overdraft, subsidence)
- Outflows of groundwater storage supply (losses)
- Water quality of native groundwater
- Seawater intrusion
- Estimation of safe yield
- Regulatory permitting for possible storage of reclaimed water

## **3.5 Marine Transport**

Marine transport is a relatively new concept for water supply in California. Proposals range from hauling fresh water from as far away as Alaska, carried by either pulling large plastic bags behind ships or retrofitting oilrigs to carry water instead of oil.

**Table 3-4**  
**Summary of Supply Options for City of San Diego**

Supply Option	Existing Supply (AFY)	Range in Potential Supply (AFY)	Range in Unit-Cost (\$/AF) <sup>1</sup>
Water Conservation	21,000	42,000 (by 2030)	\$50 - \$75
Water Reclamation	8,000 <sup>2</sup>	33,000	\$300 - \$600
Groundwater Desalination (Safe Yield Supply)	0	6,000 – 20,000	\$650 - \$1,200
Groundwater Storage (Dry Year Supply)	0	10,000 – 48,000	\$550 - \$700
Ocean Desalination	0	10,000	~ \$1,400
Marine Transport	0	20,000	~ \$700
Central Valley Water Transfers (Dry Year Supply)	0	10,000 – 60,000	\$500 - \$580 (untreated)
Imported Supply from CWA/MWD (Firm Dry Year Supply)	175,000 <sup>3</sup>	200,000	\$430 - \$600 (untreated)

<sup>1</sup> Range in unit cost reflects cost of existing supplies and ranges of potential cost for new supplies.

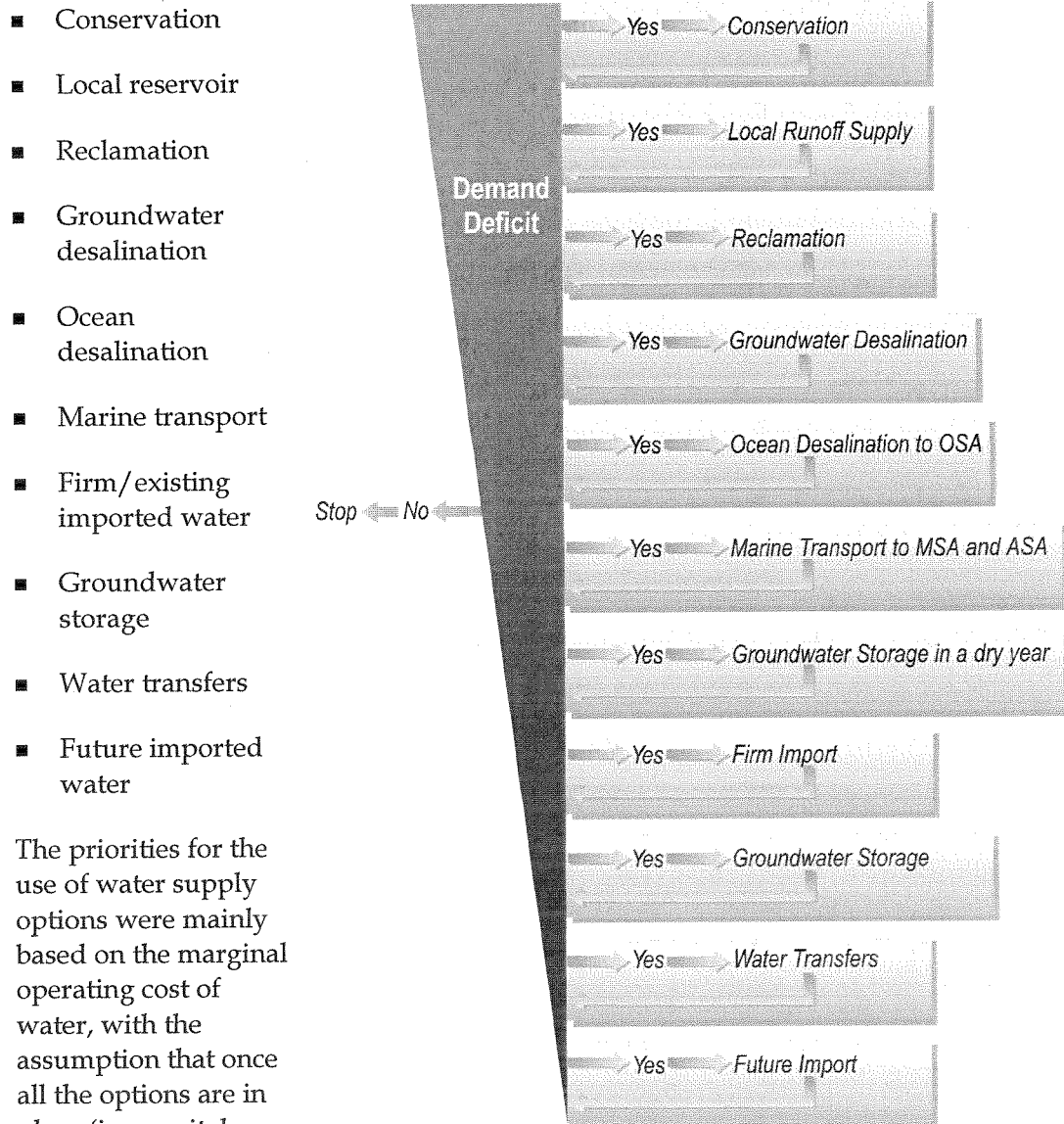
<sup>2</sup> Although the City is currently delivering about 4,000 AFY of reclaimed water, it has the system capacity to deliver 8,000 AFY without the need for additional facilities.

<sup>3</sup> The City can get as much as 260,000 AFY from imported water during normal and wet years. However, in a repeat of a critically dry event, such as 1977, the estimated firm imported supply will be 175,000 AFY. This estimate assumes imported water will be allocated based on need, rather than preferential rights.

after local supplies are utilized are met by imported water, distributed to minimize remaining supply deficits. Figure 6-2 illustrates the location of the water supply options in the City's system. Water supply flows in the model followed the conceptual representation depicted in Figure 6-4.

### *Priorities for the Use of Water Supply Options*

In order to supply each service area demand with a sufficient, and not excessive, demand, priorities were set to establish an order in which each supply is utilized. The following is the priority order in which the supplies are developed:



The priorities for the use of water supply options were mainly based on the marginal operating cost of water, with the assumption that once all the options are in place (i.e., capital investments have been made to establish a water supply option), the marginal operating cost of water dictates the decision on whether

**Figure 6-5**  
**Water Supply Priorities Used in the Model**

RESOLUTION NUMBER R- 297484

ADOPTED ON DEC 09 2002

WHEREAS, on August 12, 1997, the City Council adopted the *Strategic Plan for Water Supply (Strategic Plan)* that included a water resources strategy to meet future water demands through 2015, identified a nine-year Capital Improvements Program (CIP) to upgrade, replace and expand key water system facilities, and approved a rate increase to fund the initial years of the CIP; and

WHEREAS, by the year 2030, San Diego's population and economic growth is projected to increase water demands by almost 50 percent over 2002 levels; and

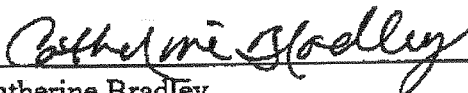
WHEREAS, a long-range water resources plan is necessary to define a flexible strategy for the next 30 years and develop evaluation tools for continued water resources planning; and

WHEREAS, the Water Department, together with its consultant and the Citizen's Advisory Board, have developed a long-range water resources plan;

NOW, THEREFORE, BE IT RESOLVED, that the Council hereby adopts the City of San Diego Long-Range Water Resources Plan (2002-2030) as set forth in the document on file in the office of the City Clerk as Document No. RR - 297484

APPROVED: CASEY GWINN, City Attorney

By



Catherine Bradley  
Deputy City Attorney

CB:cbs

11/8/02

Or. Dept: Water

R-2003-657

# Exhibit 44



THE CITY OF SAN DIEGO

# Mission Valley Basin

## FACT SHEET



Mission Valley Well

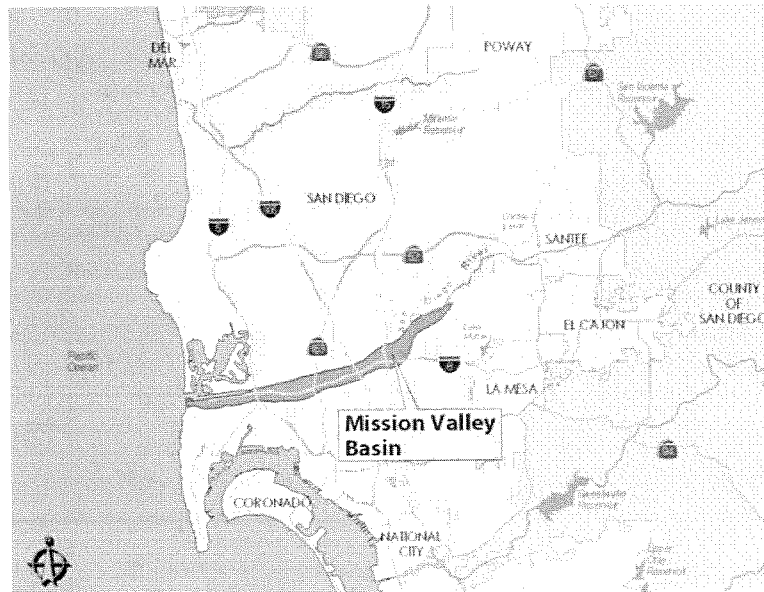
*A water resource strategy that includes conservation, recycled water, and groundwater supplies will help meet future water needs.*



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## Developing Potable Water Supplies

One of the top priorities of the City of San Diego is developing new local water supplies and storage. The use of groundwater reduces reliance on imported water supplies and contributes to a regional effort to reduce demands for imported water.



### Basin Overview

The Mission Valley Basin is located in the central region of the city. Since 1986 petroleum products have been discharged into the ground affecting the quality of groundwater in the basin. In 1992, a clean-up order was issued to the responsible party by the Regional Water Quality Control Board. Insufficient clean-up efforts could impact city's plan to implement project.

### Basin Capacity

Approximate yield and storage capacity of the basin is 2,000 to 4,000 acre-feet per year (AFY) and 42,000 AF respectively.

**Project:** Mission Valley Brackish Groundwater Desalination Project

**Estimated Cost:** \$25 million

**Estimated Timeline:** 4-5 years

This project would extract and desalinate native groundwater through reverse osmosis resulting in approximately 2,000 AFY of groundwater. Desalinated water would be conveyed locally to the distribution system in Mission Valley. Joint efforts by the United States Geological Survey and the city are underway to collect and analyze groundwater data to estimate water supply potential of the basin. A deep monitoring well was drilled in 2005 as part of this effort.

# Exhibit 45



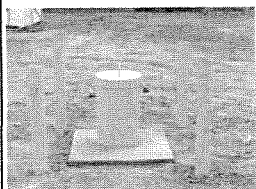
THE CITY OF SAN DIEGO

# San Diego Formation Basin

## FACT SHEET

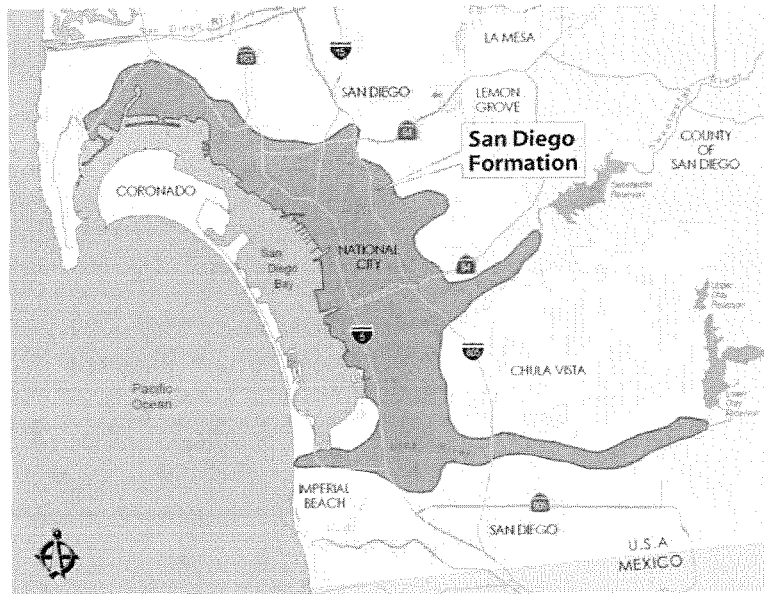
### Developing Potable Water Supplies

One of the top priorities of the City of San Diego is developing new local water supplies and storage. The use of groundwater reduces reliance on imported water supplies and contributes to a regional effort to reduce demands for imported water.



Mount Hope Well

*A water resource strategy that includes conservation, recycled water, and groundwater supplies will help meet future water needs.*



#### Basin Overview

The San Diego Formation is located in the Southwest region of the city, south of Interstate 8 and north of State Route 905.

#### Basin Capacity

Approximate yield of the basin is 10,000 acre-feet per year (AFY) and approximate storage capacity is 200,000 AF.

**Project:** San Diego Formation Brackish Groundwater Desalination Project

**Estimated Cost:** \$45 million

**Estimated Timeline:** 4-5 years

**Planning Study:** \$500,000

**Planning Study Grant Funding:** Approximately \$375,000

The brackish groundwater desalination project would extract and desalinate native groundwater through reverse osmosis. As a result, approximately 5,000 AFY of groundwater would be produced. The water could then be distributed locally in the area.

A planning study is underway to estimate the basin's desalination potential. As part of the study, a monitoring well was drilled to characterize the water quality and quantity of the basin. The information gathered by the monitoring well will help to determine the preferred method of desalination technology used in the basin.



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# Exhibit 46

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**Public Review Draft**

**San Pasqual Basin Groundwater Management Plan**

**August 2007**

*Prepared For:*

**City of San Diego Water Department**

*Prepared By:*

**MWH Americas, Inc.  
9444 Farnham Street, Suite 300  
San Diego, CA 92123**

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## Public Input Sought On Draft 2007 San Pasqual Groundwater Management Plan (GMP)

**Comments will be accepted through October 22, 2007**

The City of San Diego is evaluating and implementing opportunities to use groundwater as an integral part of its water supply portfolio. As part of this process, the City is asking for input from the public regarding the Groundwater Management Plan (GMP).

While San Diego relies on surface water, the 2002 Long-Range Water Resources Plan makes new groundwater supplies a priority. The objective of the GMP is to enhance and understand the long-term sustainability and quality of groundwater within the San Pasqual groundwater basin, and protect this groundwater resource for beneficial uses including agriculture, the environment and water supply.

The draft GMP is available by [download](#) (PDF: 3.9Mb) or by calling (619) 533-7572.

Please email your comments to Elpidia Zaragoza at the City of San Diego at [ezaragoza@sandiego.gov](mailto:ezaragoza@sandiego.gov) or mail them to: City of San Diego Water Department, 600 B Street, Suite 600, MS 906, San Diego, CA 92101. Comments may also be made in person at the San Diego City Council public hearing. The hearing date will be noticed two weeks in advance in the Daily Transcript, the North County Times, and on the city's website. The public comment period closes October 22, 2007.

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## **Appendix B**

### **Summary Descriptions of Groundwater Management Planning Efforts in the Vicinity of San Diego**

## **Borrego Water District**

The Borrego Water District's service area is located approximately 50 miles to the east of the SPGMP area (Error! Reference source not found.). The Borrego Water District Groundwater Management Plan (BWDGMP) was adopted on October 18, 2002. The goal of the BWDGMP is as follows:

*"The goal of this study is to provide a long-range groundwater management plan for the Borrego Valley that will minimize overdrafting of the aquifer and enhance the recharge capabilities while providing a dependable supply of water for the reasonable growth of the valley. This plan should do so in a manner that is equitable to the current users of the aquifer and economically feasible for future users."*

The components of the BWDGMP are based upon the CDWR Draft Guidelines and include reliability, public input, regional groundwater management, integrated planning, management objectives, data monitoring and evaluation, implementation, and periodic re-evaluation.

The BWDGMP contains the following nine BMOs:

- 1) Adopt programs and approaches to groundwater management that will incrementally reduce the annual decline in water levels of monitored wells;
- 2) Evaluate all programs adopted for groundwater management to assess their impact on the long-term water resources of the adjacent land in the state park;
- 3) Implement programs to improve the measurement of all water uses in the valley;
- 4) Develop additional programs to measure the water resources of the aquifer;
- 5) Establish standards for reduction of water use for all categories of land use and develop programs to meet those standards;
- 6) Maintain water quality throughout the valley at the current standard;
- 7) Assure that the appropriate agencies, particularly the BWD, evaluate any new land use in terms of its projected impact upon the valley's groundwater resources;

- 8) Work with public and private entities to acquire agricultural land from willing sellers; and
- 9) Determine the maximum amount of water that can be obtained from adjacent basins and evaluate programs to acquire land and construct the necessary facilities to make maximum use of these resources.

### **San Luis Rey Municipal Water District**

The San Luis Rey Municipal Water District's service area is located approximately 20 miles to the north of the SPGMP area (Error! Reference source not found.). A groundwater management plan document was completed in 1996. There is no information regarding whether the plan has been implemented.

### **Sweetwater Authority**

The Sweetwater Authority's service area is located approximately 30 miles to the southwest of the SPGMP area (Error! Reference source not found.). An interim GMP was developed for the Sweetwater Authority to commence groundwater management in the area until a subsequent plan is adopted by the Sweetwater Authority Governing Board, pursuant to Water Code Section 10750 et seq. (AB3030).

The Sweetwater Valley basin is described in the State of CDWR Bulletin Number 118 as basin number 9-17 (CDWR, 2003). Implementation of the groundwater management plan involves managing groundwater levels and protecting groundwater quality within the watershed of the Sweetwater River, the Sweetwater Valley basin, and the San Diego Formation within the service area of the Sweetwater Authority.

The groundwater management strategies as described in the interim plan include the following:

- Maintain static groundwater levels
- Protect groundwater from pollution by man-made activities
- Monitor seawater intrusion
- Monitor groundwater quality and quantity
- Sweetwater Authority groundwater projects

- Develop new or expanded groundwater supplies
- Development of relationships with state and local regulation agencies – United States Bureau of Reclamation (USBR) and United States Geological Survey (USGS)

The interim plan states that Sweetwater Authority will maintain a database of groundwater levels and water quality for existing monitoring wells within the Sweetwater Valley basin.

### **Rainbow Valley Basin Groundwater Management Plan**

The Rainbow Valley service area is located approximately 15 miles to the northwest of the SPGMP area, adjacent to Riverside County (Error! Reference source not found.). The Rainbow Valley Basin Groundwater Management Plan (RVBGMP) was prepared in accordance with the Water Code Section 10750 et seq. (AB3030).

The Rainbow Valley basin is located within the Rainbow Valley Watershed, which is a 5,864 acre watershed. The Rainbow Valley basin is surrounded by foothills of granitic rock. The increased storage of water in the aquifer has led to high water tables, failure of septic systems, and perennial flow of Rainbow Creek. The majority of the water imported into the basin is used for irrigation of agricultural land.

The objectives of the RVBGMP are related to the use of only imported water, the high water table, and poor water quality. The following objectives have been identified in the RVBGMP:

- Provide a safe, reliable local water supply,
- Reduce dependence on imported water by developing a new local groundwater supply,
- Lower the groundwater table within the Rainbow Valley east of I-15,
- Improve water quality (both surface and groundwater), and
- Educate the agricultural and residential communities regarding best management practices they can implement.

The RVBGMP was developed as the first comprehensive study of the hydrologic conditions of the Rainbow Valley basin, including compilation and analysis of previously collected data and additional data collection and monitoring to fill data gaps. The recommended future actions include additional data collection and feasibility studies to investigate the potential for groundwater production projects. Additional data will help to develop a better understanding of the basin and ultimately determine the potential for extraction of groundwater from the residual aquifer.



THE CITY OF SAN DIEGO

# San Pasqual Basin

## San Pasqual Brackish Groundwater Desalination Project

### FACT SHEET

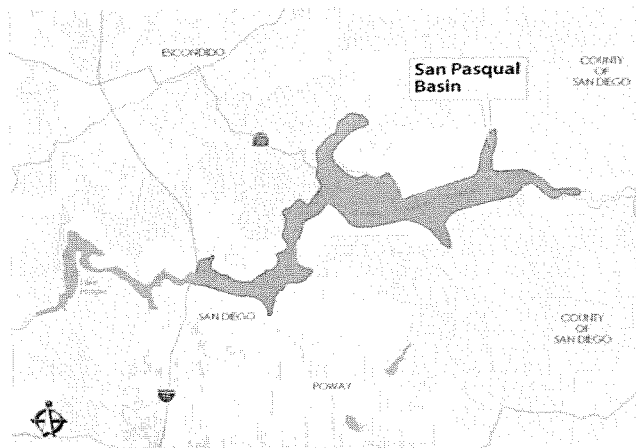
*A water resource strategy that includes conservation, recycled water, and groundwater supplies will help meet future water needs.*



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### Developing Potable Water Supplies

One of the top priorities of the City of San Diego is developing new local water supplies and storage. The use of groundwater reduces reliance on imported water supplies and contributes to regional efforts to reduce demands for imported water.



#### Basin Overview

The San Pasqual Basin is located approximately 25 miles northeast of downtown San Diego. The Sutherland Reservoir is located upstream of the basin, and Lake Hodges is located downstream. The total surface area of the groundwater basin is approximately 4,540 acres.

#### Basin Capacity

Approximate storage capacity is 58,000 acre-feet (AF) and approximate yield is 5,800 acre-feet per year (AFY). A Groundwater Management Plan for the San Pasqual basin was adopted by the city council in 2007.

### San Pasqual Brackish Groundwater Desalination Project

**Estimated Project Cost:** \$45 million

**Estimated Project Timeline:** 4-5 years

**Planning Study Cost:** \$3 million

**Planning Study Grant Funding:** Approximately \$1.5 million

The brackish groundwater desalination project would extract and desalinate native groundwater through reverse osmosis treatment. The desalinated water would then be conveyed directly to the city's potable water system. The project would produce 5,000 AFY of potable water and 800 AFY of brine, requiring disposal.

A planning study is underway to research the feasibility of building a desalination facility and identifying brine disposal alternatives. The study cost is projected at \$3 million and approximately \$1.5 million in State grant funding has been acquired.

# Exhibit 47



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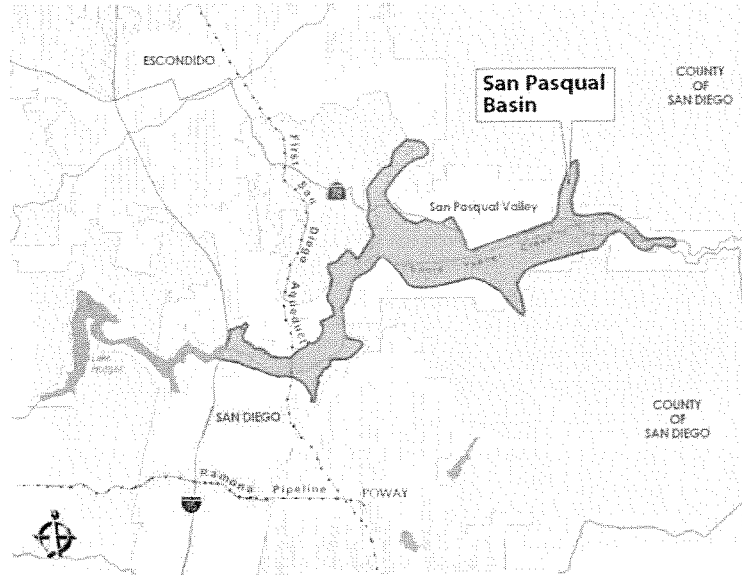
# San Pasqual Basin

## San Pasqual Conjunctive Use Storage and Recovery Project

### FACT SHEET

### Developing Potable Water Supplies

One of the top priorities of the City of San Diego is developing new local water supplies and storage. The use of groundwater reduces reliance on imported water supplies and contributes to regional efforts to reduce demands for imported water.



*A water resource strategy that includes conservation, recycled water and groundwater supplies will help meet future water needs.*

#### Basin Overview

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#### Basin Capacity

Approximate storage capacity is 58,000 acre-feet (AF) and approximate yield is 5,800 acre-feet per year (AFY). A Groundwater Management Plan for the San Pasqual basin was adopted by the city council in 2007.

### San Pasqual Conjunctive Use Storage and Recovery Project

**Estimated Cost:** \$39 million

**Estimated Timeline:** 4-5 years

**Planning Study Cost:** \$950,000

**Planning Study Grant Funding:** \$750,000

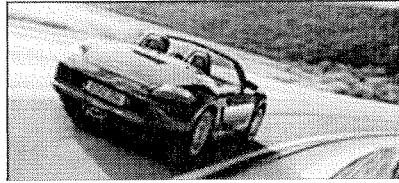
The conjunctive use project would operate by storing up to 10,000 AF of imported water in the aquifer during periods of availability and taking it out for use when needed. Imported water would be delivered from the First San Diego Aqueduct to the basin and stored by means of percolation. Stored water would be recovered by extraction wells.

A planning study is underway to research the feasibility of storing and recovering raw water in the upper (eastern) basin. The study cost is projected at \$950,000 and \$750,000 in local grant funding has been acquired.



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## Why Desalination Doesn't Work (Yet)

By Michael Schirber, Special to LiveScience  
posted: 25 June 2007 08:49 am ET

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With water fast becoming a hot commodity, especially in drought-prone regions with burgeoning populations, an obvious solution is to take the salt out of seawater. Desalination technology has been around for thousands of years, after all. Even Aristotle worked on the problem.

Tantalizing as desalinated water might sound, the energy costs have made it rather unpalatable.

"Until recently, seawater desalination was a very expensive water source solution," said Gary Crisp, an engineer for the Water Corporation of Western Australia.

Drinking seawater straight is a bad idea because your body must expel the salt by urinating more water than it actually gains. Seawater contains roughly 130 grams of salt per gallon. Desalination can reduce salt levels to below 2 grams per gallon, which is the limit for safe human consumption.

Currently, between 10 and 13 billion gallons of water are desalinated worldwide per day. That's only about 0.2 percent of global water consumption, but the number is increasing.

"There is significant growth in desalination capacity throughout the world, and it is anticipated to continue for

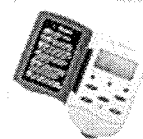
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Currently, between 10 and 13 billion gallons of water are desalinated worldwide per day. That's only about 0.2 percent of global water consumption, but the number is increasing.

"There is significant growth in desalination capacity throughout the world, and it is anticipated to continue for sometime," says Stephen Gray of Victoria University.

Gray has been chosen to lead a new research program in Australia—where many regions lack fresh water supplies—to improve the efficiency of desalination plants.

### **Aristotle's efforts**

Back in the 4th century B.C., Aristotle imagined using successive filters to remove the salt from seawater.

But the first actual practice of desalination involved collecting the freshwater steam from boiling saltwater. Around 200 A.D., sailors began desalinating seawater with simple boilers on their ships.

The energy required for this distillation process today makes it prohibitively expensive on a large scale. A lot of the current market for so-called "thermal desalination" has therefore been in oil-rich, water-poor countries in the Middle East.

Since the 1950s, researchers have been developing

membranes that could filter out salt, similar to what Aristotle originally envisioned. Presently, this membrane technique, sometimes called "reverse osmosis," requires one-fourth of the energy and costs half of the price of distilling saltwater.

"In the last ten years, seawater reverse-osmosis has matured into a viable alternative to thermal desalination," Crisp says.

### **Energy is key**

But even with membranes, large amounts of energy are needed to generate the high pressure that forces the water through the filter. Current methods require about 14 kilowatt-hours of energy to produce 1,000 gallons of desalinated seawater.

A typical American uses 80 to 100 gallons of water a day, according to the U.S. Geological Survey. The entire country consumes about 323 billion gallons per day of surface water and another 84.5 billion gallons of ground water.

If half of this water came from desalination, the United States would need more than 100 extra electric power plants, each with a gigawatt of capacity.

Depending on local energy prices, 1,000 gallons of desalinated seawater can cost around \$3 or \$4. Although that might not seem like much, it is still cheaper in many places to pump water out of the ground or import it from somewhere else.

But the price difference will undoubtedly narrow, especially in regions that could experience more intense droughts owing to climate change.

Water use has been growing twice as fast as population growth, causing more and more communities to suffer water shortages. The demand for freshwater supplies will drive prices higher, making desalination increasingly attractive.

### **Brainstorming on membranes**

The number of desalination plants worldwide has grown to more than 15,000, and efforts continue to make them more affordable.

Last month, Australia's largest scientific research agency joined with nine major universities in a membrane research program to reduce desalination energy costs, as well as maintenance costs associated with gunk sticking to membranes and fouling them up.

"Lowering the energy required for desalination and the fouling propensity of membranes are the two biggest challenges facing desalination," Gray says.

A team of diverse researchers will try to tackle these problems by developing new types of membrane materials. The goal is to cut in half the energy required for desalination.

"We would hope to have something available within the next 10 years," Gray said.

# Exhibit 49

# Supply from the Sea—Exploring Ocean Desalination

By Jeff Szytel, P.E.

As the world's population continues to expand into areas of limited water supply, planners and politicians will have little option but to turn to the ocean as a supplemental source of fresh water. Although there are still many barriers to large scale implementation of ocean desalination (desal), advances in technology, water policy, economic allocation and public awareness will continue to drive the development of ocean desalination projects well into the foreseeable future.

This article provides a brief overview of ocean desal including global and domestic trends, a comparison of desalination technologies, a summary of the economics involved, and a summary of implementation considerations.

## Ocean Desalination Trends

Ocean desal as a source of drinking water is not a new concept. Egyptian, Persian, Hebrew and Greek civilizations studied various desalination processes. Aristotle and Hippocrates both advocated the use of distillation in the 4th century B.C. By 2001, there were more than 15,000 ocean desal plants worldwide with a total production capacity of nearly 6.2 billion gallons per day. Most ocean desal facilities are located along the coasts in the energy-rich Middle East. However, ocean desal is a growing market in Spain, England, the United States, and Mexico. Trends impacting advancement of ocean desal in the U.S. and abroad include improvements in technology, increased governmental subsidy, increased consideration of co-location with power plants and more private/public approaches to project development.

## Better Technology

Nothing has contributed to ocean desal's increasing viability and growth as much as the continuing improvements in technology. In 1959, the first reverse osmosis (RO) membrane was developed by Loeb and Sourirajan at the University of California, Los Angeles. These original cellulose acetate

researchers and manufacturers continue to improve the efficiency of high-pressure pumping and energy recovery systems and the effectiveness of RO pretreatment. These technological advances have contributed to a substantial decrease in the capital, operations, and maintenance costs of RO for ocean desal.

## Regional subsidies

Although technological advances continue to reduce the cost of ocean desal, its economic viability is usually limited when compared to alternative sources of additional freshwater supply. However, the inevitability of ocean desal as a viable freshwater source is causing some regional water agencies to subsidize the development of large-scale desal projects. Examples of agencies promoting large-scale ocean desal projects include Tampa Bay Water in Florida and the Metropolitan Water District of Southern California. Additionally, state and federal agencies such as the Texas Water Development Board and the U.S. Department of Energy continue to offer grants and financial incentives in support of desal. These subsidies not only create a market that drives private investment into research and development, but allow some water suppliers to begin to economically integrate ocean desal into their existing supply portfolio.

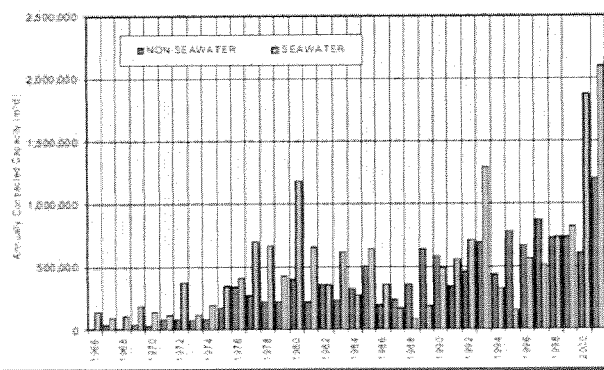
## Co-location with Power Generation Plants

Throughout North America and Europe, ocean desal plants are almost exclusively co-located with power generation facilities. This trend can be attributed to the ready availability of a reliable and inexpensive source of electricity, availability of existing intake and outfall structures, and potential for utilizing a higher temperature feed water source. Since energy usage is one of the most significant cost factors when considering ocean desal on a life-cycle basis, reliable and inexpensive energy can dramatically decrease its overall cost.

Utilizing existing intake and outfall structures not only limits the environmental impact of a new ocean desal facility, but can also substantially reduce construction cost. Environmental impact is limited during construction since new sub-marine facilities are usually not required. Impact is limited during operation since the return flows from power plant cooling systems offer a significant pre-dilution for the concentrated brine waste discharge. Additional benefits may be gained by drawing the RO feed water from the power plant's spent cooling water. With a warm water feed, RO membranes can operate at a higher rate (flux), which can reduce pressure and/or footprint requirements. However, with warmer feed water, salt rejection across the RO membranes is typically diminished and multiple "passes" of RO membranes may be needed to achieve similar product water quality.

## Private/Public Project Development

Considering the limited large-scale application of ocean desal in the U.S., project development typically involves significant risk related to maintaining environmental compliance, implementing advanced technology, ensuring treatment performance, maintaining system reliability and controlling operations and maintenance costs. Interested water utilities and public agencies must therefore develop approaches to mitigate these risks. Developers have attempted to fill this need by promoting their ability to deliver new ocean desal plants while applying approaches to manage overall



Annually contracted global desal capacity.

Source: European Desalination Society Newsletter Issue 18, 2003, Pages 7 & 10, The Development in Seawater Desalination.

membranes allowed researchers to apply high pressure to separate ionic species from water molecules, producing fresh water from a salty solution.

Since the early days of RO, there have been significant advances in membrane technology to improve salt rejection and reduce transmembrane pressure and membrane fouling. RO membrane manufacturers continue to refine the manufacturing, packaging and fabrication processes. Additionally,

*continued on next page*

project risk. These may include options contracting and bundled procurement approaches including design-build and design-build-operate. Although third-party private developers have helped promote and implement ocean desal throughout the U.S., their role will likely diminish as the market matures and public water agencies become more comfortable managing these risks directly.

## Is Ocean Desal Cost Prohibitive?

When considered on a cost-per-volume treated basis, the cost of ocean desal has decreased dramatically over the last 20 years. For example, the Tampa Bay Water desalination facility is expected to deliver water at a total cost of around \$2 per 1,000 gallons. When this trend is superimposed onto a curve representing the cost of other new supplies in areas with limited supply options (such as expanded import systems), "crossover" is either eminent or has already occurred. There is no question that ocean desal is an expensive solution for obtaining additional freshwater supply. However, in some areas of the country where population growth will far outstrip the availability of "conventional" freshwater sources, ocean desal may in fact be the "least cost" alternative for new supplies.

Although a straight comparison of cost per volume of new freshwater supply is an important first step in considering the economics of new sources of supply, this approach fails to take into account an equally important factor: source reliability. Associated with each new supply is an inherent reliability. Contributing factors may include regional weather patterns, environmental regulations, infrastructure condition, natural disasters, and variability in water quality. Water agencies must consider their ability to provide sufficient fresh water to their customers under a wide range of reliability conditions.

Financial analysis offers a useful analogy when considering supply economics. As every investor knows, the first rule of financial management is diversification. Each investment has an inherent risk and return. By combining investments of varying risk and return, an optimally "efficient" portfolio can be achieved, which maximizes the return for a given level of aggregate risk. The same approach can be applied to water supply planning; however, instead of considering risk versus return, water planners consider reliability versus cost. Although ocean desal represents a relatively high-cost supply alternative, it can be highly reliable. Therefore, by combining ocean desal with lower cost, lower reliability supplies, water managers can achieve an optimally "efficient" supply portfolio that maximizes reliability for a given aggregate cost.

## Getting the Salt Out—Comparing Technologies

There are two primary mechanisms for ocean desal: thermal processes and membrane processes. Thermal processes rely upon induced evaporation to separate water vapor from a salt solution, followed by a condensation step that returns the water vapor to liquid form. Membrane processes rely upon selectively permeable membranes that reject dissolved ions while allowing water molecules to pass under high pressure.

Thermal processes include multi-effect distillation (MED), multi-stage flash distillation (MSF), and vapor compression (VC). Membrane processes include reverse osmosis and sequential nanofiltration (the Long Beach Method). A brief comparison of thermal and membrane processes is in the table accompanying this article.

## From Vision to Reality—Implementing Ocean Desal

As with any large investment in capital facilities for water supply, implementation of ocean desalination requires the application of thorough and

comprehensive management and engineering approaches. Significant considerations may include: supply planning and economics; water quality analysis; site evaluation; technology evaluation (pilot testing, pretreatment, configuration, fouling, etc.); energy considerations; residuals management options; environmental compliance and facility permitting; public outreach; supply integration; project aesthetics; and project procurement options.

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	MEMBRANE PROCESSES (RO)	THERMAL PROCESSES (Distillation)
<b>Installation</b>	<ul style="list-style-type: none"> <li>• Prepackaged modules</li> <li>• High mobility of modular system (ideal for emergency water supply use)</li> <li>• High space/production capacity ratio (400-1,000 gal/day/sq.ft.)</li> </ul>	<ul style="list-style-type: none"> <li>• Can easily be combined with electric-power generation</li> </ul>
<b>Pre-Treatment</b>	<ul style="list-style-type: none"> <li>• Scaling prevention</li> <li>• Fouling prevention (fine filtration for suspended solids removal + acid addition for microbial growth prevention)</li> <li>• pH adjustment for compatibility with membranes</li> </ul>	<ul style="list-style-type: none"> <li>• Scaling prevention</li> </ul>
<b>Post-Treatment</b>	<ul style="list-style-type: none"> <li>• Degasification</li> <li>• pH adjustment</li> <li>• Addition of Ca and HCO<sub>3</sub> (to the level of 100 ppm CaCO<sub>3</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>• Degasification</li> <li>• pH adjustment</li> <li>• Addition of Ca and HCO<sub>3</sub> (to the level of 100 ppm CaCO<sub>3</sub>)</li> </ul>
<b>Waste Generation</b>	<ul style="list-style-type: none"> <li>• Brine disposal</li> <li>• Backwash</li> <li>• Used filter cartridge</li> </ul>	<ul style="list-style-type: none"> <li>• (hot) Brine disposal</li> <li>• Cleaning solution</li> </ul>
<b>Operation and Maintenance</b>	<ul style="list-style-type: none"> <li>• Shut-down for cleaning every 4 months</li> <li>• Membrane replacement every 3 to 5 years</li> <li>• Cartridge filter elements replacement about every 8 weeks</li> <li>• Preventive maintenance (instrument calibration, pump adjustment, chemical feed inspection and adjustment, leak detection and repair, structural repair)</li> <li>• Main operational concern: fouling</li> </ul>	<ul style="list-style-type: none"> <li>• 1 annual shut-down of 6 to 8 weeks for general inspection and maintenance (damage repairing, scale removal, vacuum system cleaning, pump inspection)</li> <li>• Corrosion and scaling more important (increases with temperature)</li> </ul>
<b>Water Quality</b>	<ul style="list-style-type: none"> <li>• 300-500 ppm TDS</li> <li>• Limited removal of VOCs</li> <li>• Risk of bacterial contamination of the membranes</li> </ul>	<ul style="list-style-type: none"> <li>• 1-50 ppm TDS</li> <li>• Cannot remove VOCs</li> </ul>
<b>Energy Requirements</b>	<ul style="list-style-type: none"> <li>• For pressurization of membrane</li> <li>• 4.7-9.73 kWh/m<sup>3</sup> for RO</li> </ul>	<ul style="list-style-type: none"> <li>• For heating</li> <li>• 2.83-5.67 kWh/m<sup>3</sup> for MSF</li> <li>• 2.02-4.04 kWh/m<sup>3</sup> for MEE</li> <li>• 8.08-12.12 kWh/m<sup>3</sup> for VC (not including thermal energy)</li> </ul>
<b>Costs</b>	<ul style="list-style-type: none"> <li>• Capital Cost: \$1,000-\$1,600 m<sup>3</sup>/d</li> <li>• Production Cost: \$0.45-\$0.67/m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Greater potential for economies of scale</li> <li>• Capital Cost: \$900-\$2,000 m<sup>3</sup>/d</li> <li>• Production Cost: \$ 0.46-\$1.50 /m<sup>3</sup></li> </ul>

## Trend Toward Design-Build

continued from page 1

or wastewater from the client's system using various technologies. This is paramount since data from plant or test runs using non-system water or wastewater will not reflect the true conditions for the given treatment system's parameters.

Over time, influent parameters may vary, leading to less than perfect treatment solutions that were based on pilot tests for the plant. Testing should include variations in the influent water/wastewater quality parameters to allow for changes out of the client's or design-builder's control.

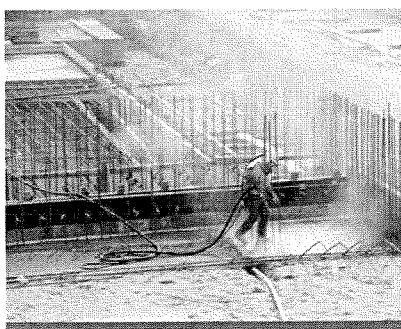
### Design-Build Benefits

The design-build process can save time compared to conventional project delivery methods. Various studies including those by the Construction Industry Institute indicate that the design-build delivery approach can lead to as much as a 30 percent reduction in the overall project duration. Much of it is because of the fast-track design and construction. A specific example is the West Basin Municipal Water District Water Recycling plant Membrane Design-Build Phase III expansion project in El Segundo, Calif. This microfiltration-reverse osmosis (MF-RO) project was completed in approximately 18 months, compared to a 24-month schedule for the same project if using conventional design-bid-build.

In addition to saving time, single-source responsibility leads to a reduction in change orders and third-party claims. Design-build also reduces the client's need to referee between the designer and contractor regarding responsibility for fixing any mistakes. There is a reduced workload on the owner's staff as much of the review process is handled by the design-builder or the owner's design-build program manager.

In some cases, choosing a design-build operate (DBO) process can save money as well as reduce risks. There is some data based on completed projects, which shows that combining operations into a design-build contract can pare the operating costs from 20 to 40 percent. It cannot be said that any given project would save that much, since each project has its own variables. Still, this preliminary data indicates there may be an additional benefit

to the municipality if the operations are considered to be part of the delivery method. Using DBO alleviates the risk of operations costs many years into the future by placing the risks on the DBO team.



A worker sandblasts a portion of the south trench for West Basin's new No. 9 reverse osmosis treatment train.

As membrane technology gains ground, different vendors will compete for larger portions of the water and wastewater treatment market, and interchangeability may become an issue. If the utility selects one vendor, but later another vendor develops a better membrane or method, the utility will not be able to take advantage of the improvement, unless costs of making the change are reasonable, the benefits are substantial, or both. If the DBO provider has a vested interest in the utility's bottom line and the expertise to evaluate technological improvements, the utility will have a motivated and highly qualified partner to suggest and implement modifications.

### Putting Design-Build Into Practice

West Basin Municipal Water District has utilized design-build for many of its membrane-related projects. A case in point is their current Phase IV expansion for the MF-RO capacity addition, as well as for upgrades to their Title 22 reclaimed water treatment system. The project is underway and is scheduled to be completed in two calendar years using design-build. This project would easily take two-and-a-half to three years using design-bid-build. The key benefit to the client is being able to sell treated water to its clients earlier, a significant advantage at an approximate savings of \$ 10,000 per day.

Design Build Institute of America (dbia.org) is

working with public sector agencies throughout the country to help them understand the pros and cons of design-build, both on the project execution level and the legislative level. It is predicted that by the year 2010, half of all public sector projects will utilize some form of the design-build project delivery method.

Design-build is an important delivery alternative though it is not a panacea for all projects. Membrane technology, with its ever-increasing improvements and lowered costs per unit, will become a more attractive solution for water and wastewater treatment. Using the innovative single-source solution with both the engineer and contractor involved from the beginning, the client often benefits when it receives the end product. It is expected that the increased use of design-build in the membrane application arena will bring positive results for many years to come.

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